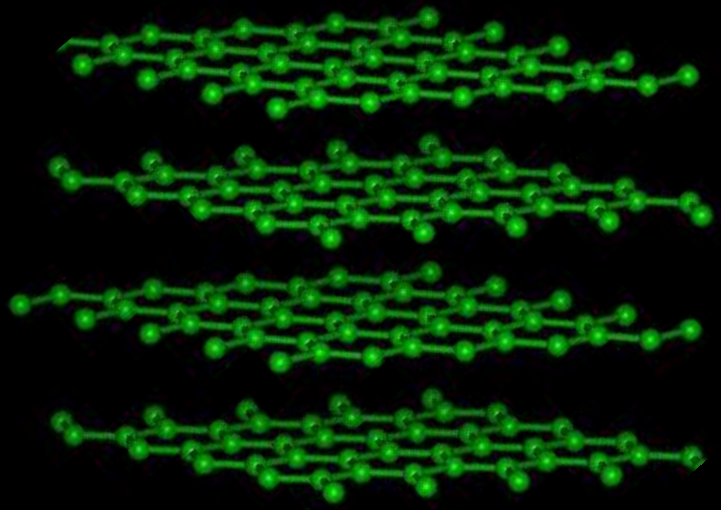
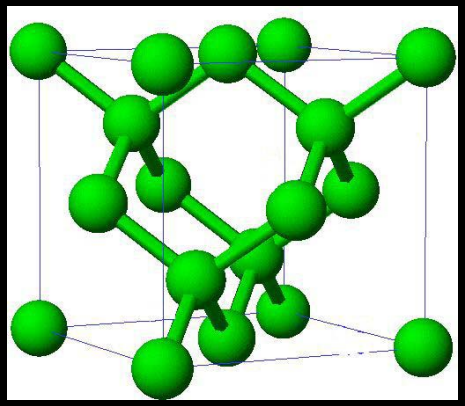
X Rays, Neutrons, and the Nanometer

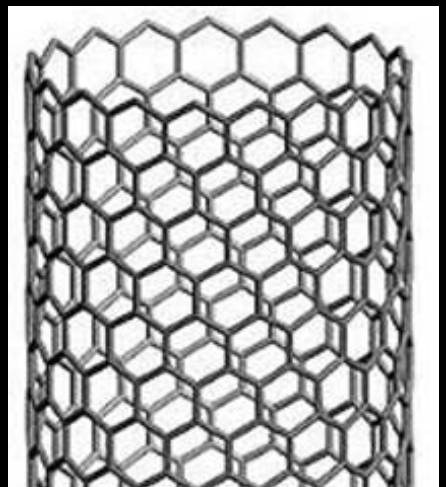
Dr. Patricia M. Dehmer
Director, Office of Basic Energy Sciences
Office of Science
U.S. Department of Energy

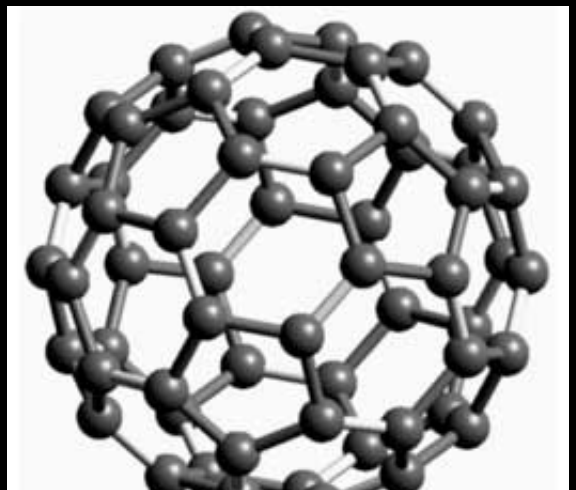
16 June 2005
National Nanotechnology Workshop
X-rays and Neutrons: Essential Tools for Nanoscale Research

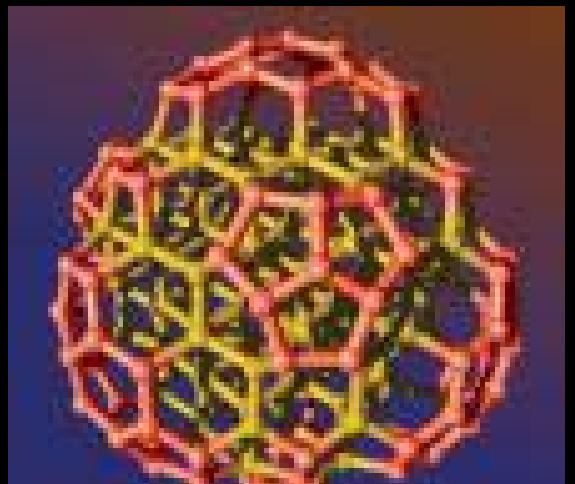
Things Built of Carbon











Early Tools for Examining Things Tiny

Late 1600s

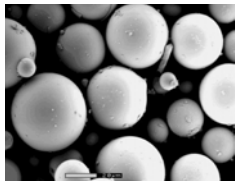
1908

Things Natural

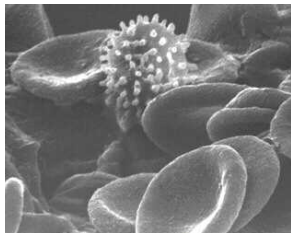
ust mite
200 μm

nan hair
20 μm wide

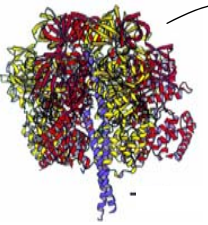
Ant
~ 5 mm



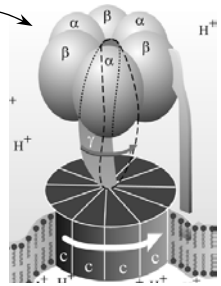
Fly ash
~ 10-20 μm



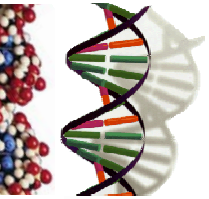
Red blood cells
with white cell
~ 2-5 μm

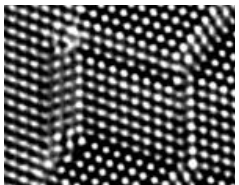


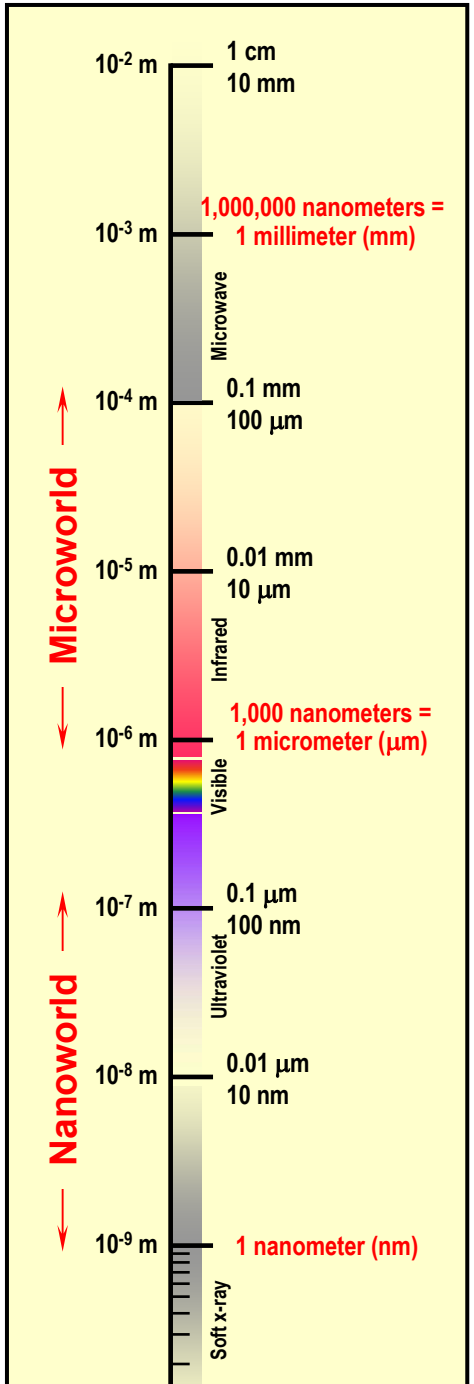
~10 nm diameter



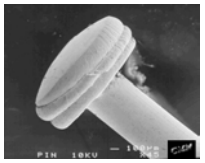
ATP synthase



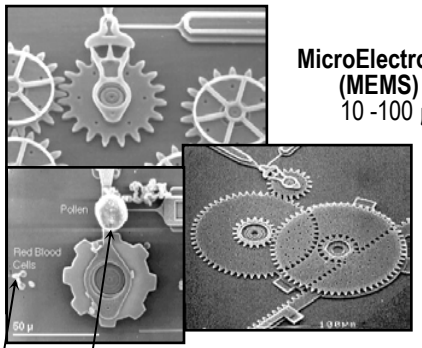




Things Manmade

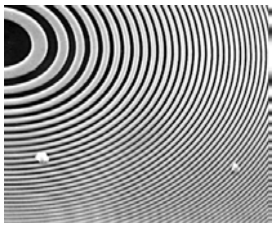


Head of a pin
1-2 mm

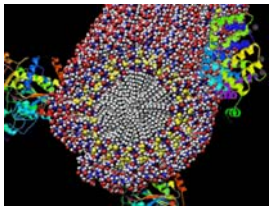


MicroElectroMechanical
(MEMS) devices
10 -100 μm wide

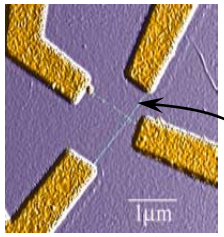
Pollen grain
Red blood cells



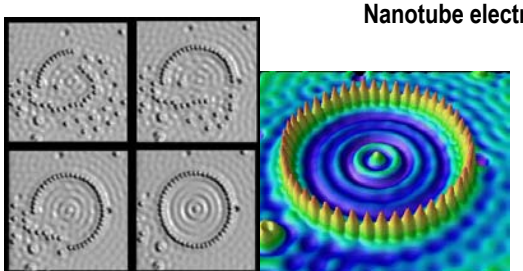
Zone plate x-ray "lens"
Outer ring spacing ~35 nm

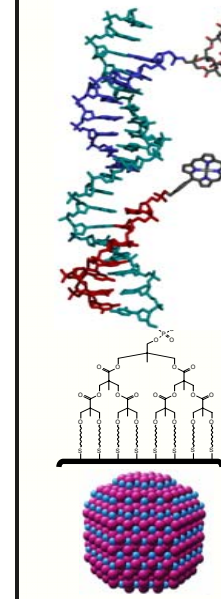


Self-assembled,
Nature-inspired structure
Many 10s of nm



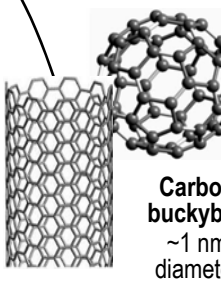
Nanotube electrode





The Challe

Fabricate and com nanoscale building blocks to make use devices, e.g., a photosynthetic rea center with integra semiconductor sto



Carbo buckyb ~1 nm diamet

Carbon nanotube
~1.3 nm diameter

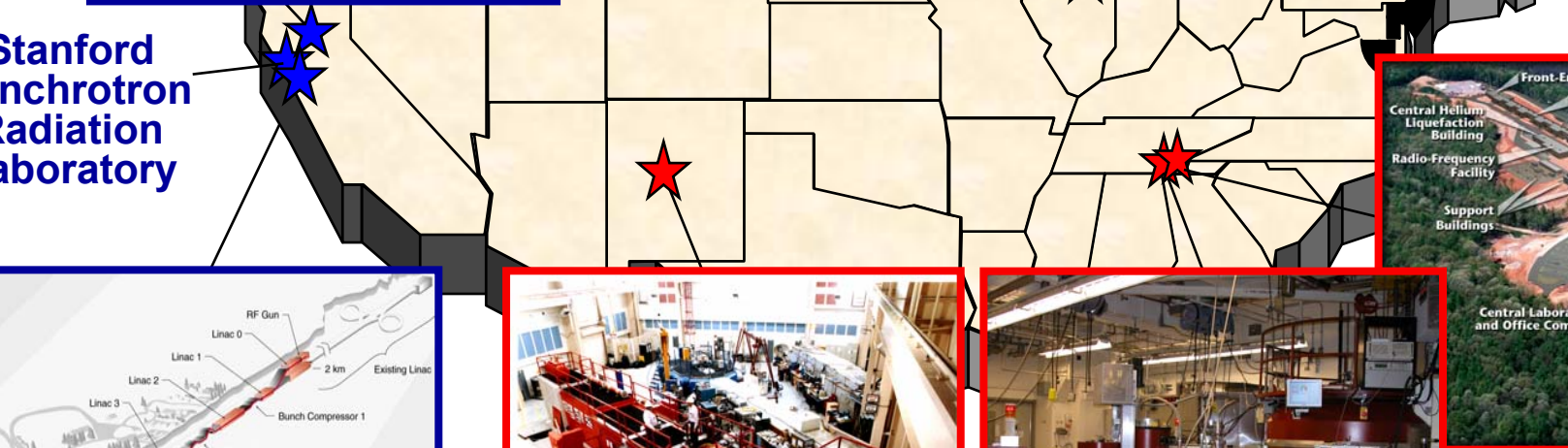
BES Facilities for X-ray and Neutron Scattering

vanced Light Source

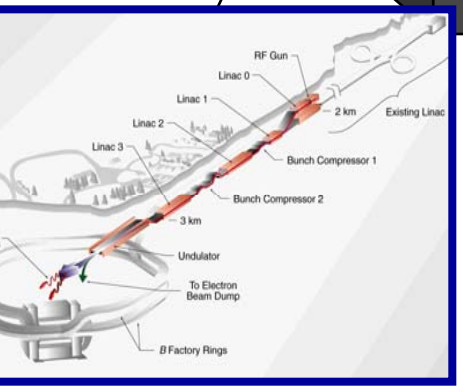
Advanced Photon Source

National Synchrotron Light Source

Intense Pulsed Neutron Sourc



Stanford nchrotron Radiation aboratory



Spallation Neutro Source

The Spallation Neutron Source (SNS)

Facilities (under Construction) for the Synthesis, Characterization, and Study of Nanoscale Materials

All five DOE Nanoscale Science Research Centers are in construction, with commissioning beginning in FY 2006. ($114M in engineering design and construction in FY 2005)

Center for Functional Nanomaterials
(Brookhaven National Laboratory)

Center for Nanoscale Materials
(Argonne National Laboratory)

Molecular Foundry
(Lawrence Berkeley
National Laboratory)

Center for Nanophase Materials Sciences
(Oak Ridge National Laboratory)

Center for Integrated
Nanotechnologies

Nanoscale Science Research Centers – Actual Photos

Center for Nanoscale Materials
(Argonne National Laboratory)

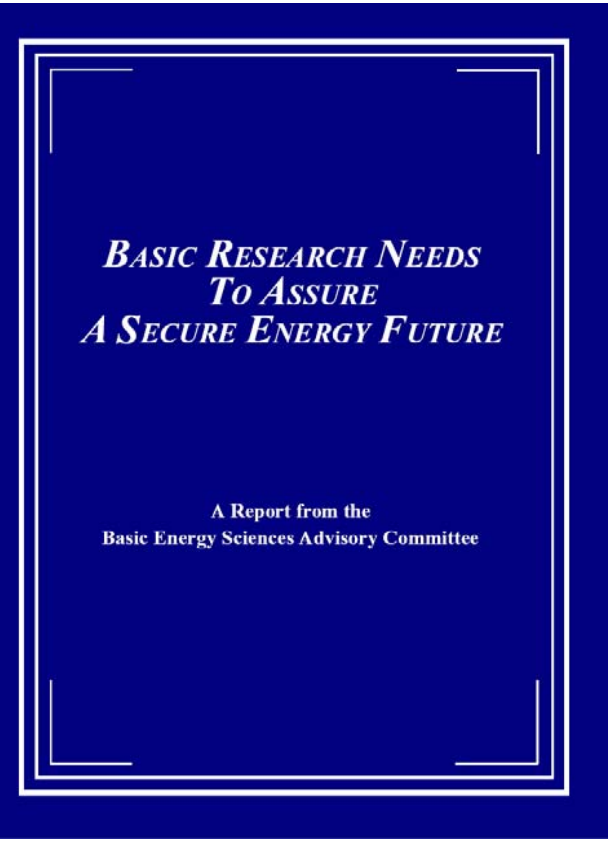
Molecular Foundry
(Lawrence Berkeley National Laboratory)

Center for Nanophase Materials Sciences

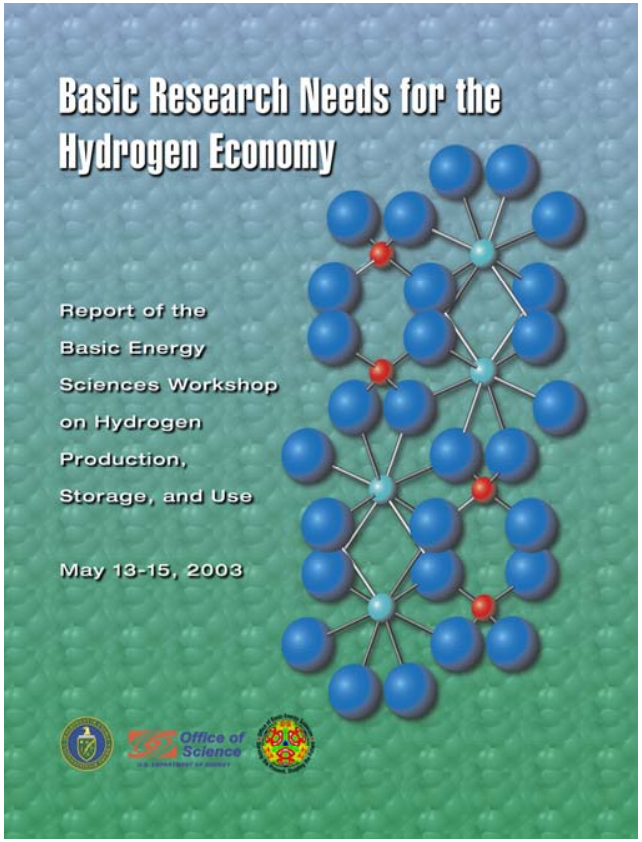
Center for Integrated Nanotechnologies


MODEL
N600-ES
LOG LOG
SPEED RULE
POST
SYNCHRO SCALE
CRAY I/O
CRAY

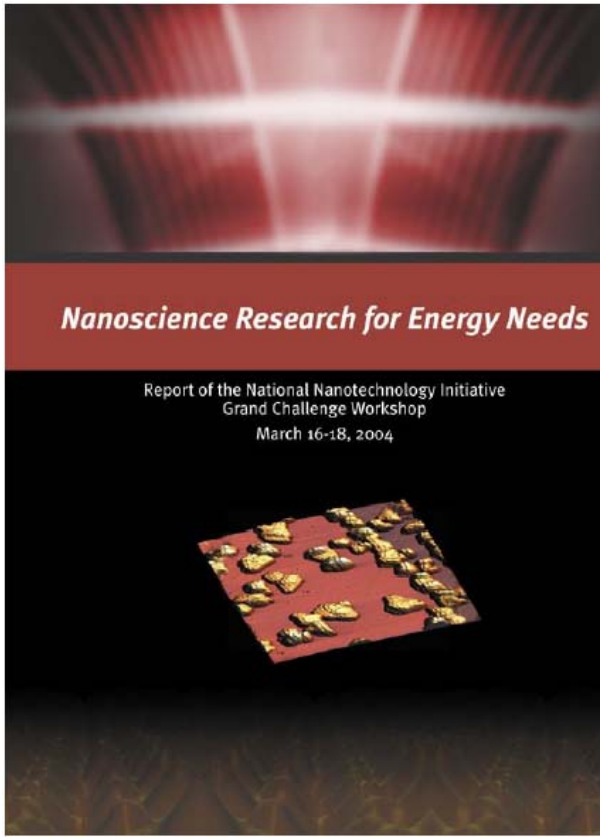
Basic Research and Our Energy Future



BESAC Workshop: October 21-25, 2002
Report: March 2003
Dr. John Stringer, EPRI, Chair
Dr. Linda Horton, ORNL, Co-Chair



BES Workshop: May 13-15, 2003
Report: Summer 2003
Professor Millie Dresselhaus, Chair
Dr. Michelle Buchanan, Co-Chair
Dr. George Crabtree, Co-Chair



NSET Workshop: March 16-18, 2004
Report: June 2004
Dr. Robert Hwang, Co-Organizer
Professor Ellen Williams, Co-Organize